ISSUE PAPER
DIESEL EXHAUST PARTICULATE EMISSIONS AND NR 445

April 2001

ISSUES

Three issues related to diesel exhaust particulates have arisen during the process of revising Ch. NR 445, Wisconsin's hazardous air pollutant regulation:

- Should diesel exhaust particulate be added to NR 445 as a probable carcinogen?
- If so, should the exemption for diesel fuel combustion in NR 445 be maintained?
- If not, how should sources of diesel exhaust particulates be regulated?

RECOMMENDATIONS

- Diesel exhaust particulate emissions should be listed in NR 445 as a probable carcinogen.

  They have been identified as such by both the International Agency for Research on Cancer and the National Toxicology Program. This dual listing is the basis upon which the Department has included known and probable carcinogens in NR 445.

- Emissions from the combustion of diesel fuel should not be exempt from the control requirements in NR 445.

  Air regulations that limit diesel exhaust emissions for the purpose of meeting the particulate matter and NO_x ambient air quality standrad are not protective of public health from a cancer risk perspective. Staff analysis showed that the many of permitted diesel generators have allowable emission levels with a cancer risk that could exceed 1 in 100,000. Furthermore, there has been a marked increase in the number of permits issued for diesel-fueled electric generators and this demand is expected to continue. The Department currently lacks the regulations to require measures to reduce the cancer risk.

- Emissions from stationary and portable diesel-fueled engines should be regulated as a source category in NR 445.

  The NR 445 emission standard for probable carcinogens is Best Available Control Technology. Staff recommends that source category performance-based standards be established instead of the case-by-case BACT determination for existing sources. This is a more efficient approach in cases, such as diesel generators, where the emission sources, operational characteristics and available control options are very similar or are limited.

  Under the recommended proposal, new and modified compressed ignition (CI) engines combusting fuel oil would be required to install best available control technology. Existing CI engines would be required to use low sulfur diesel fuels and to either limit their total fuel usage or to install control technology. Existing sources would have up to three years to comply with the regulatory requirements, with the ability to be granted an extension. CI

engines using less than a specified amount of fuel would be exempt from BACT or performanced-based requirements. The permit exemption for emergency electric generators would be maintained.

BACKGROUND

History and Description of NR 445

Ch. NR 445, Wis. Adm. Code, Wisconsin's hazardous air pollutant (HAP) regulation, was promulgated in 1988. Its purpose is to protect public health and prevent public health problems that may result from the inhalation of hazardous air pollutants emitted by stationary sources. Over 430 chemicals are regulated under NR 445 for their cancer and/or non-cancer health effects.

Carcinogens are listed in NR 445 if they are identified as known or probable carcinogens by both the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP). IARC is part of the World Health Organization; NTP is a U.S. Department of Health and Human Services program. Both are highly respected scientific groups. Currently there are 125 chemicals listed in this category. The emission standards are technology based, since there is no known "safe" level for carcinogens.

Non-carcinogens include chemicals with acute and chronic health effects to the respiratory, nervous, reproductive systems or to other organs such as the kidney or liver. Chemicals with acute health effects are included if they have a threshold limit value established by the American Conference of Governmental and Industrial Hygienists (ACGIH), with some exceptions. Chemicals with chronic health effects are included if they have a US EPA derived reference concentration limit and an uncertainty factor of 300 or less. There are 362 chemicals listed as having acute health effects and 24 as having chronic health effects. The emission standard for the non-carcinogens is to meet an ambient air concentration.

Diesel Exhaust Emissions in NR 445

In 1988, diesel exhaust emissions were not listed by either IARC or NTP as a known or probable carcinogen, nor were they identified as having an acute non-cancer health effect. Therefore they were not listed as a hazardous air pollutant in NR 445. Diesel was included in the definition of fossil fuels for which an exemption from NR 445 requirements was included in the rule.

In 1994, diesel exhaust emissions were among the chemicals added to NR 445 because of their long-term non-cancer health effects. Their exemption from complying with NR 445 requirements was not removed because the emissions from combustion of diesel fuel were unlikely to exceed the ambient air concentration standard based on it's US EPA reference concentration.

NR 445 Rule Revision Process

In early 2000, the Bureau of Air Management began the process of updating NR 445 and established a Technical Advisory Group (TAG), which has been meeting on a regular basis since February 2000.

The rule revision process includes:

- Reviewing the literature to identify proposed additions and modifications to the list of NR 445 chemicals based on new scientific knowledge,
- Recommending improvements to the regulatory framework (including alternative compliance options, streamlining initiatives and generally making the rule easier to understand),
- Evaluating existing exemptions in NR 445 to determine whether they should be maintained, modified or eliminated, and recommending regulatory options if the determination is made that they should be modified or eliminated,
- Revising related rules, including the emission inventory and permitting rules.

ISSUE ANALYSIS

Should Diesel Exhaust Particulate be added to NR 445 as a Probable Carcinogen?

Since NR 445 was promulgated in 1988, there is new scientific evidence linking diesel exhaust particulates to cancer. Numerous studies document the fact that diesel exhaust, which includes diesel particulate, poses a serious threat to human health. Approximately 30 epidemiological studies indicate that there are increased lung cancer risks associated with diesel emissions. Diesel exhaust is a hazardous mixture that contains over 40 chemicals listed by US EPA and the California Air Resources Board (CARB) as toxic air contaminants. In 1989, the International Agency for Research on Cancer (IARC) concluded that diesel exhaust is a "probable" carcinogen. In 1998, the California Air Resources Board listed particulate emissions from diesel-fueled engines as a Toxic Air Contaminant. And, in 2000, the National Toxicology Program (NTP) issued its Ninth Report to Congress on Carcinogens in which it designated diesel exhaust particulate as "reasonably anticipated to be a human carcinogen". IARC and NTP are the two internationally and nationally recognized organizations of science health professionals to which the Department looks for the scientific basis for identifying chemicals posing a cancer health risk. A chemical or chemical compound is listed in NR 445 as a known or probable carcinogen only if it is identified as such by BOTH agencies. Diesel exhaust particulates meet these criteria.

One factor that contributes to the adverse health impacts is that most diesel particulate is in the inhalable particle range (10 microns in diameter), with 94% of the mass less than 2.5 microns in diameter. Fine particulate matter penetrates into the deepest regions of the lungs and poses the greatest threat to human health.

The California Scientific Review Panel, which advises CARB, has quantitatively evaluated the risks associated with diesel exhaust. Based on human epidemiological studies, they have assigned a range of risks to diesel exhaust particulates such that exposure to one microgram per cubic meter (1 ug/M3) of air over a lifetime might represent a risk in the range of 130 in a million to 2,400 in a million.[1]

[1] *A risk level of 1 in a million implies a likelihood that up to one person out of one million equally exposed people would contract cancer if exposed 24 hours per day to the specific concentration over an assumed lifetime of 70 years. This would be in addition to those cancer cases that would normally occur in an unexposed population of one million people.*

It is fair to say that there is some heated debate about the cancer potency factor that California has developed. The California process for adopting health risk values and identifying toxic air contaminants is extremely thorough, with public debates and scientific panels. After hearing both sides of the diesel toxicity debate, the California Air Resources Board Scientific Review Panel recommended that diesel exhaust be listed as a toxic air contaminant. According to risk and exposure estimates from California, as much as 70% of the cancer risk associated with urban air may be attributed to diesel exhaust from stationary and mobile sources.

US EPA issued a revised draft Health Assessment Document for Diesel Exhaust in July 2000. This document has been reviewed by the Clean Air Scientific Advisory Committee (CASAC). In October 2000, CASAC reached unanimous closure on the document, pending key revisions. The Health Assessment Document (HAD) concludes that diesel exhaust is likely to be a human carcinogen at environmental exposure levels. While US EPA did not believe that a potency (or unit risk factor) could be derived at this time, the assessment presents a perspective about the possible magnitude of risk from environmental exposure to diesel exhaust emissions. The inclusion of a range of cancer risk values in the HAD was debated by CASAC. The CASAC members unanimously agreed that the range would be included, but accompanied by clear caveats and disclaimers concerning the uncertainty of the risk, the use of the risk perspective values and the fact that the possible lower end of the risk range includes zero. The HAD analyses indicate that the lifetime cancer risk could range from 1 in 100,000 to 1 in 1,000. This range indicates the potential significance of the lung cancer hazard and is not a definitive quantitative characterization of risk by US EPA.

Diesel exhaust emissions are also associated with a number of long term non-cancer effects, including chronic bronchitis, inflammation of the lung tissue, immunological allergic reactions, and airway constriction. US EPA has established a reference concentration for diesel exhaust particulates to protect sensitive individuals from chronic or long-term non-cancer health effects. Diesel exhaust particulates are already listed in NR 445 for their chronic non-cancer health effects.

Staff recommends that diesel exhaust particulates be listed in NR 445 as a probable carcinogen. They have been identified as such by both the International Agency for Research on Cancer and the National Toxicology Program. This dual listing is the basis upon which the Department has included known and probable carcinogens in NR 445

Should diesel exhaust particulates be exempted from NR 445 regulatory requirements?
Staff Analysis of Diesel Exhaust Emissions

Emissions from the combustion of fossil fuels are currently exempted from NR 445. Fossil fuels includes coal, natural gas and diesel fuel, as well as some others. At the September 2000 meeting of the NR 445 Technical Advisory Group, staff presented an analysis of the fossil fuel exemption, as it applied to coal combustion emissions from utility and industrial boilers. The analysis concluded that coal combustion emissions did not pose a public health risk from inhalation exposure and that the NR 445 exemption for coal, residual and distillate oils, and natural gas continued to be appropriate for external combustion boilers.

Staff has recently conducted a similar analysis of diesel exhaust particulate emissions. The analysis was based on the allowable emission levels[2] included in permits issued to over 200 diesel generators in Wisconsin. Briefly, the analysis[3] used air dispersion modeling to determine the ambient air impact of nine diesel generator configurations that are representative of permitted diesel generators in Wisconsin. Modeling was performed for each of Wisconsin's five meteorological regions. The estimated range of lung cancer risk associated with each of these nine configurations in each meteorological region was then calculated. The higher risk level reflected the highest ambient impact found; the lower risk, the lowest ambient impact. The analysis was conducted using the range of risk factors that California's Scientific Review Panel found in the literature (130 in a million to 2,400 in a million) and US EPA's range of risk factors (12 to 1,200 in a million).

Staff also conducted a source-specific air dispersion modeling analysis for 47 of the diesel generators permitted. This analysis was based on the specific generator configuration and site characteristics, permit limitations and meteorological conditions that applied to each generator. As shown in Table 2, this analysis found that 20 of the 47 generators are expected to have a risk greater than 1 in 10,000 using the CARB lower bound unit risk factor (130 in a million).

It is important to note that these two analyses assessed the risks from individual sources and do not represent the cumulative risk from multiple generators in an area, nor do they account for other sources of diesel exhaust emissions, such as trucks or buses, or for emissions of other hazardous air pollutants from the same or adjacent industrial or manufacturing operations. In addition, several of the permitted generators failed their particulate emissions compliance tests, exceeding their allowable limits.

Increase in number of diesel generators

In Wisconsin, as throughout the country, there has been a marked increase in stationary diesel engine activity. Diesel generators have long been used to provide back-up power for facilities where the delivery of power was critical (such as hospitals) or where reliable electricity supply was essential (as in certain commercial enterprises). They have also been used to provide power at remote sites where it was not economical to extend electric lines (such as, sand and gravel quarries). Their use for emergency or peak shaving electric generation however has been increasing in the past few years. Since 1999, the Department has issued permits to electric utilities for 193 diesel generators and is processing permits for an additional 42 units. The total megawatt capacity of these units is 370 megawatts, comparable to the Pulliam Power Plant (coal-fired) or the fully expanded Germantown Plant (gas-fired). In total, over 400 diesel generators

[2] *Diesel generators must meet state and federal emission limits for stationary sources. New "major" air pollution sources must install best available control technology. Diesel generators, however, seldom if ever have emissions exceeding major source applicability thresholds. These are minor sources, or take permit restrictions to be minor sources, and therefore are not required to install emission control technologies. Limits necessary to protect the National Ambient Air Quality Standards (NAAQS) for particulate matter and/or nitrogen oxides become the most limiting for diesel generators. Emergency electric generators (those which operate for less than 200 hours and are 3000 kW or smaller) are exempt from permit requirements and do not undergo review for air quality impacts. Currently, there are no state or federal requirements to limit toxic emissions from these sources.*

[3] *See Appendix 1 for more details on the methodology and findings.*

have been permitted since 1999. These do not include emergency electric generators that are exempt from permit requirements.

In addition to the permitted generators, there are an unknown number of other generators scattered throughout the state. The fact that there are over 50 diesel generators at UW-Madison alone suggests that the number may be large.

Distributed generation is expected to continue to grow as a force in electric supply for energy providers and customers. The US Department of Energy forecasts that distributed generation could provide as much as 20 percent of all new US power generation capacity additions by 2010. There are a number of reasons for this, including: increasing demand for electricity, difficulty in siting new power plants and transmission lines, restructuring within the electric power industry, expanding customer needs for extremely reliable power supply and technological advances that have made distributed generation more cost effective.

Distributed generation consists of small generating units, generally between 2 kilowatt to 50,000 kilowatts, that are sited close to or at a customer's location. Distributed energy can be low emitting sources such as fuel cells and microturbines or high emitting sources such as diesel generators. Diesel generators are a low cost, proven technology and are relatively unregulated. As the Public Service Commission's December 2000 "Report to the Legislature on the Development of Distributed Electric Generation in the State of Wisconsin" notes, the challenge is to provide incentives for properly sited, small-scale, high-efficiency electric generating facilities and guard against the potential that "the recent air quality improvements could be reversed if numerous small, uncontrolled sources of (diesel) generation are installed". (p. 14)

Staff concludes that the NR 445 exemption for diesel fuel combustion emissions is no longer appropriate and recommends that the exemption be eliminated. Other air regulations that limit diesel exhaust emissions are not protective of public health from a cancer risk perspective. Staff analysis showed that many of the permitted diesel generators have allowable emission levels with a cancer risk that exceeds 1 in 100,000. Furthermore, there has been a marked increase in the number of permits issued for diesel-fueled electric generators and this demand is expected to continue. The Department currently lacks the regulations to require measures to reduce the cancer risk.

How should sources of diesel exhaust particulates be regulated in NR 445?
Proposed Regulatory Approach

The NR 445 emission standard for probable carcinogens that emit over a threshold level is Best Available Control Technology (BACT). BACT is the maximum degree of reduction practically achievable, taking into account energy, economic and environmental impacts and other costs related to the source. It is determined on a case-by-case basis.

An alternative approach is to regulate emissions from diesel-fueled CI engines as a source category and to establish emission standards for these sources in the rule. This approach is analogous to the approach being proposed for Good Wood Combustion and can be thought of as establishing a presumptive BACT that would apply to all affected CI engines, rather than requiring each CI engine to undergo a case-by-case BACT determination. Staff has developed a

regulatory proposal that would set forth the following requirements. (This proposal is explained in more detail in Appendix 2.)

1. Exempt new and existing stationary diesel-fueled CI engines that use less than a specified amount of fuel (gallons/year) from NR 445.

2. Exempt emergency electric generators (defined as those 3,000 kilowatts or less operating no more than 200 hours per year) from NR 445.

3. Require new stationary diesel-fueled CI engines to install Best Available Control Technology. BACT for new sources would not be specified in the rule because of the desire not to freeze the technology requirement at a point in time, but rather to take advantage of technology developments.

   Alternatively, this requirement could be phased as requiring new diesel-fueled CI engines to meet the most stringent particulate matter emission level that is currently being met by mobile source diesel engines, the approach being taken in the California.

4. Within 3 years of promulgating NR 445 rule revisions, require existing, non-exempt stationary diesel-fueled CI engines to use a very low-sulfur fuel and to either:
   a. Limit fuel usage to a specified amount (gallons/year), or
   b. Install a diesel particulate filter or trap, or equivalent control technology.

The proposal would also contain provisions allowing the department to approve extensions to compliance deadlines for appropriate reasons such as fuel availability.

Benefits of the Proposed Source Category Regulatory approach.

Using performance-based standards for a source category is an efficient approach in cases where the emission source, operational characteristics and available control options are very similar or are limited. This is the case with diesel generators. If well designed, a categorical approach offers the advantage of being simpler and more straightforward for sources as well as DNR permit engineers. Also, setting existing requirements in the rule creates a "more certain" future, which allows owners to make decisions regarding the future use of existing generators with full knowledge of the regulations.

Other benefits of the proposal include:

- A simple and clearly defined method for determining when a source must comply with NR 445 regulations. Exemption levels based on stack height and fuel usage are proposed to be included in the rule.
- Tiered requirements that allow a source to elect the regulatory option (limits on fuel usage or technology controls) that best meet its intended use and needs.
- Maintaining the status quo with respect to siting small, emergency generators.

OVERVIEW OF DIESEL REGULATIONS

Mobile sources are the major source of diesel exhaust emissions, contributing about 95% of the total nationwide. US EPA estimates that on-road mobile sources (trucks and buses) contribute 58% of total diesel particulate emissions and non-road mobile sources (construction, agricultural and marine equipment, recreational/commercial boats and locomotives) contribute 37%. Stationary sources contribute the remaining 5%.

In December 2000, US EPA adopted standards requiring heavy-duty trucks and buses to meet stringent tailpipe emissions beginning in 2007 and requiring low-sulfur diesel fuel beginning in 2006. US EPA estimates that the standard would result in a 90% reduction in diesel particulate emissions.

Air Management staff have prepared a draft pink sheet to adopt rules to opt-in to California's Heavy Duty Diesel Engine rule under Section 177 of the Clean Air Act. The rule would "fill the regulatory gap" between model years 2004 and 2007. The proposed "opt-in" rule would require all new, on-road vehicles with new engines beginning in Model Year 2005 to conform to emission limits adopted by the State of California. Thirteen other states have indicated that they will opt-in to the California rule. The existing federal rules will allow manufacturers subject to a consent decree to resume the sale of higher emitting vehicles at the end of model year 2004. Tighter federal rules that will be effective for Model Year 2007 and beyond will again reduce PM emissions from these heavy-duty diesel engines.

These actions address on-road mobile sources of diesel exhaust emissions. The control technologies and fuels to meet these requirements are equally useable by stationary diesel engines. The California Air Resources Board recently adopted guidance for new stationary diesel engines predicated on these technologies. The California guidance states that these technologies and fuels used by stationary sources can achieve a 90% reduction in particulate matter, the same emission reduction expected from the on-road mobile source requirements.

Some might argue that since mobile sources are the major source of diesel exhaust emissions and will be regulated, there is no need to regulate stationary sources. However, the staff analysis showed that individual generators, by themselves, posed significant cancer risks. The mobile source regulations will reduce the cumulative diesel exhaust impacts but significant risks from diesel generator emissions will remain unless action is taken to reduce these as well.

Furthermore, diesel particulate is not included in the federal list of 188 HAPs in Section 112 of the Clean Air Act. Therefore, no federal rule limiting diesel particulate from stationary soucres for health reasons can be expected. In other words, there will be no MACT standard or residual risk evaluation for diesel particulate. The current understanding of US EPA's draft MACT standards for CI engines and combustion turbines located at major sources of HAP emissions reinforces this point. The latest word on draft requirements for diesel and dual-fuel CI engines is that there will be no requirements for existing sources or new sources up to 500 Hp. Apparently there will be requirements to reduce CO from CI engines 500 Hp or larger in order to reduce the amount of organic HAP emissions from these sources.

SUMMARY AND CONCLUSION

- Diesel exhaust particulates pose a significant threat to public health. They are a probable carcinogen and have long-term non-cancer impacts.
- DNR does not currently have the regulations to limit diesel exhaust particulate emissions from stationary sources to levels that are protective of public health, from a cancer risk perspective.
- There has been a marked increase in stationary diesel activity in Wisconsin, as throughout the country.
- This increase in activity is expected to grow, as distributed generation becomes more of a force in electric supply for energy providers and customers.
- Diesel exhaust emissions from mobile sources are being regulated by US EPA.
- Diesel exhaust emissions from stationary sources will not be regulated by US EPA.
- The control technologies and diesel fuels that reduce PM emissions from mobile sources are available for use by the stationary source sector.

For all these reasons, staff recommends that diesel exhaust particulates be listed in NR 445 as a probable carcinogen, that the exemption be eliminated and that diesel-fueled CI engines be regulated as a source category.

APPENDIX 1

Staff Analysis of Diesel Exhaust Emissions

In order to evaluate the impact of maintaining the exemption for emissions from the combustion of diesel fuel, staff:

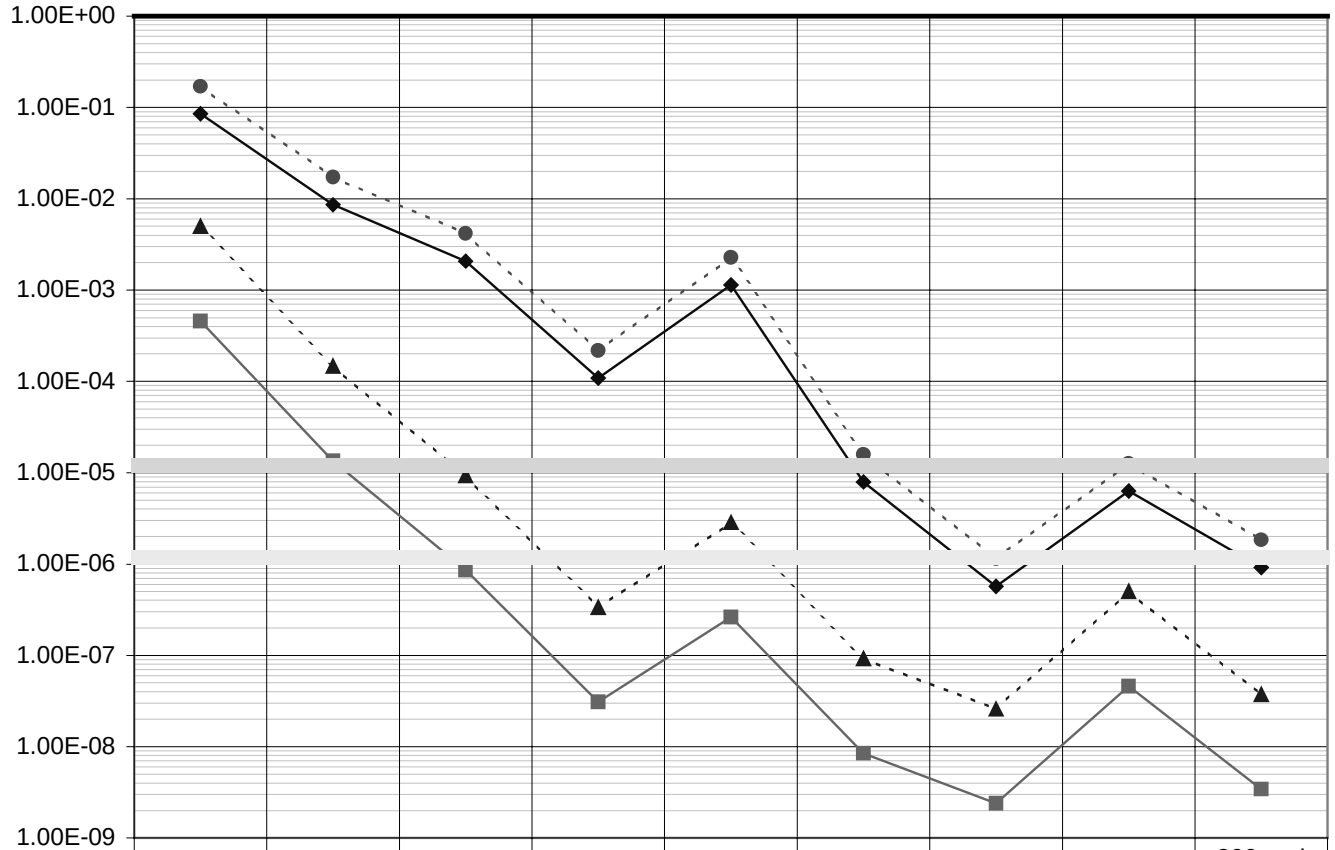
- reviewed current health information;
- reviewed and inventoried existing information and requirements on diesel generators reviewed for air permits;
- conducted an air dispersion analysis to determine the ambient impact of nine representative diesel generator configurations;
- conducted four risk assessments to describe the maximum and minimum impact of the highest emitting permitted diesel generator in each of nine configurations;
- conducted source specific risk assessments for 47 permitted generators;
- reviewed existing compliance test methods and the appropriateness of using diesel particulate as a surrogate for carcinogenic health concerns;
- reviewed the results of the emission tests performed as permitting conditions;
- reviewed the Risk Management Guidance for the Permitting of New Stationary Diesel-Fueled Engines developed by the California Air Resources Board staff.
- reviewed the US EPA Health Assessment Document for Diesel Exhaust
- evaluated the source specific impact of the generators against the reference concentration for diesel (ambient standard for chronic non-cancer health effects);

The air program has reviewed over 400 individual diesel generators for applicable requirements as part of the permitting process over the last 2-3 years. Of these 400, sufficient information was available to assess the potential impact of 200 of the generators.

File information was used along with air dispersion modeling to develop upper and lower bounds of the additional cancer risk that the generators ***individually*** could present across the state. The upper bound considered the (a) **highest** unit risk factor in the range for diesel, (b) meteorological region of the state with the **highest** impact, and (c) **highest** permitted annual emissions in each of the nine stack configurations. For the lower bound, the (a) **lowest** unit risk factor, (b) meteorological region of the state with the **lowest** impact, and (c) **highest** permitted annual emissions in each of the nine stack configurations was used. The **screening level** modeling analysis showed that the cancer risks ranged from a minimum of 3×10^{-9} (3 in a billion) to a maximum of 2×10^{-1} (2 in 10) (Table 1). The **source specific** modeling analysis showed that the cancer risks ranged from a minimum of 3×10^{-7} (3 in a ten million) to a maximum of 4×10^{-3} (4 in 1,000). These risks are from each individual generator and do not represent the cumulative risk from multiple generators in an area, nor do they account for other sources of diesel exhaust emissions, such as trucks or buses.

Table 1

Range of Annual Impacts from Highest Permited Diesel Generator (pound/year) by Stack Height (feet)



Impact Level (logarithmic scale)

e.g.,

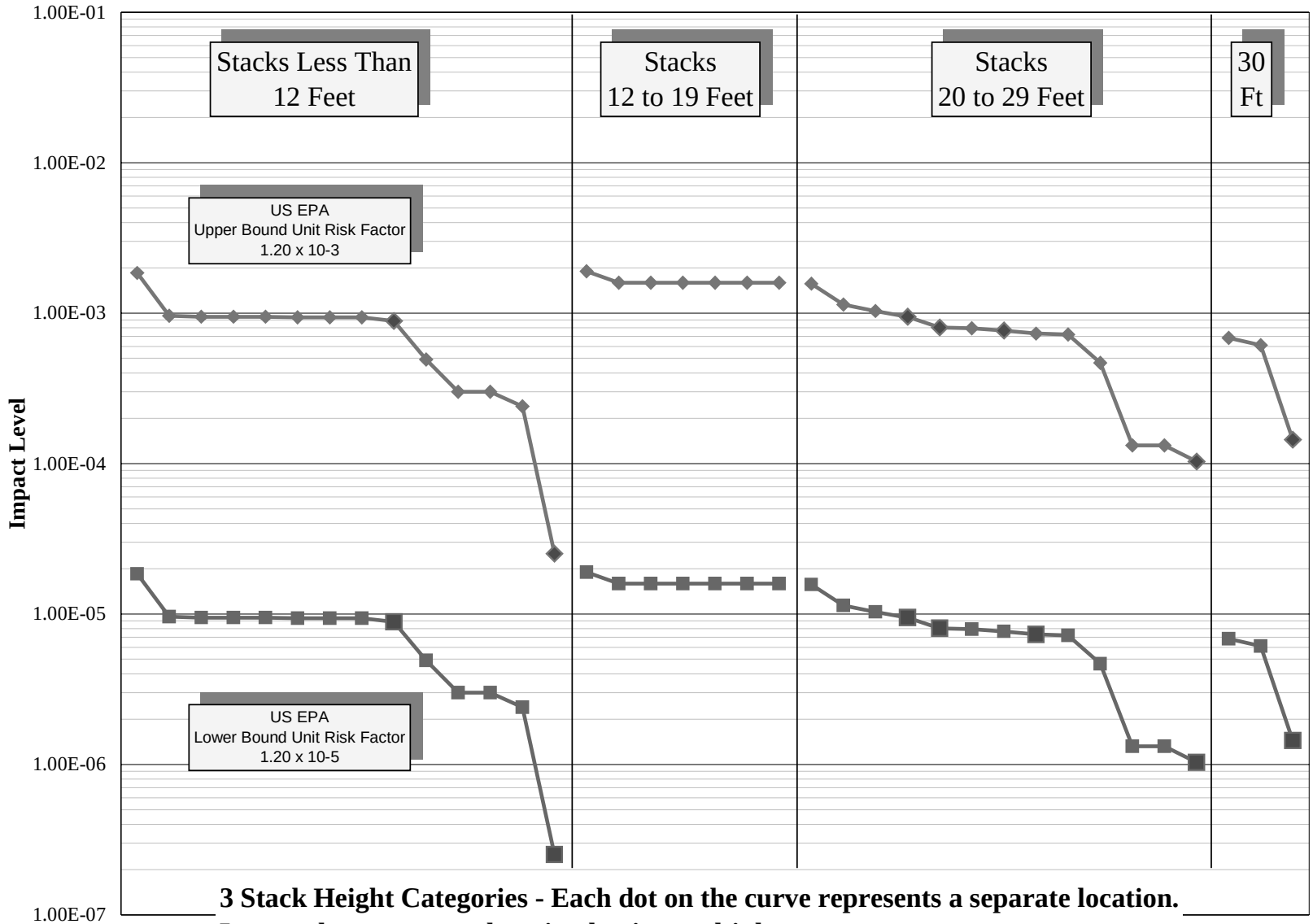
1.00E-06 =

1 in a million risk

	Area	12 to 19	20 to 29	30 to 39	40 to 59	60 to 99	100 to 199	200 to 299	300 and above
Stacks In Range	44	73	39	16	31	18	3	1	1
Upper Bound Impact (CARB 2.4x10-3)	1.71E-01	1.73E-02	4.17E-03	2.18E-04	2.28E-03	1.59E-05	1.14E-06	1.27E-05	1.84E-06
Lower Bound Impact (CARB 1.3x10-4)	4.98E-03	1.46E-04	9.31E-06	3.35E-07	2.84E-06	9.16E-08	2.59E-08	4.99E-07	3.72E-08
Upper Bound Impact (EPA 1.2x10-3)	8.53E-02	8.64E-03	2.08E-03	1.09E-04	1.14E-03	7.94E-06	5.70E-07	6.33E-06	9.21E-07
Lower Bound Impact (EPA 1.2x10-5)	4.60E-04	1.35E-05	8.59E-07	3.09E-08	2.62E-07	8.45E-09	2.39E-09	4.60E-08	3.44E-09

Source: DNR Air Pollution Permits and Applications

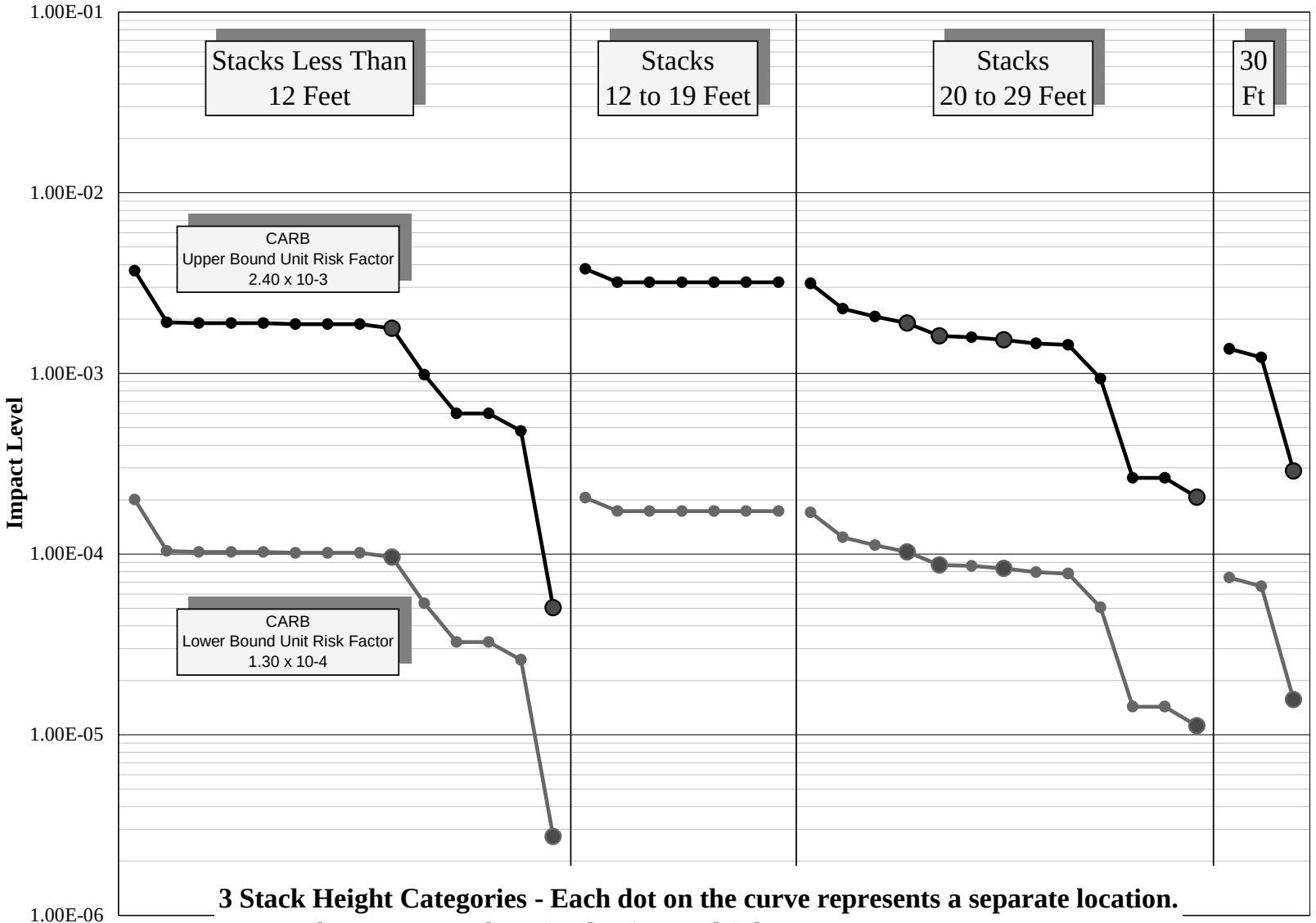
TABLE 2A: Source Specific Impacts for 47 Diesel Generators at 37 Locations (US EPA Unit Risk Factor)



3 Stack Height Categories - Each dot on the curve represents a separate location. Larger dot represents location having multiple generators.

Source: DNR Air Pollution Permits and Applications April 18, 2001

TABLE 2B: Source Specific Impacts for 47 Diesel Generators at 37 Locations (CARB Unit Risk Factor)



3 Stack Height Categories - Each dot on the curve represents a separate location. Larger dot represents location having multiple generators.

APPENDIX 2

Diesel Issue Brief Q & A

April 18, 2001